TWAS SIXTEENTH GENERAL CONFERENCE
(21–24 November 2022)

Summary of Proceedings

The Sixteenth General Conference of The World Academy of Sciences for the advancement of science in developing countries (TWAS) was successfully convened in a hybrid format from 21 to 24 November 2022, and coordinated by Zhejiang University, Hangzhou, China, and TWAS Secretariat in Trieste, Italy, in collaboration with the Chinese Academy of Sciences (CAS) and the China Association for Science and Technology (CAST).

The Conference was titled "Basic Sciences for Evidence-Based Decision-Making and Sustainable Development in the Global South," in line with United Nations General Assembly of 2 December 2021 that proclaimed 2022 the International Year of Basic Sciences for Sustainable Development, as recommended by UNESCO General Conference resolution of 25 November 2019.

TWAS Young Affiliates and the Associate Programme Manager of the Organization for Women in Science for the Developing World acted as rapporteurs reporting on the following segments: Keynote Lecture 1 and 2 of Monday, 21 November; the Ministerial Session and Symposium 1 of Tuesday, 22 November; TWAS-Abdus Salam Medal Lecture and Symposium 3 of Thursday, 24 November.

Monday, 21 November

<u>Keynote Lecture 1</u>

Title: Building our Sustainable Future through Science and Computing

Speaker: Dr. Solomon ASSEFA, Vice-President, IBM Research

Chair: Prof. Winston SOBOYEJO, President ad interim,
Worcester Polytechnic Institute, USA

Rapporteur: Dr. Rolando GITTENS, TWAS Young Affiliate (Panama)

The key message delivered by Solomon Assefa was that science and computing can help humanity achieve a sustainable future.

As Vice-President of IBM Research, Dr. Assefa operated at the nexus of technology, climate change and sustainable development, and "brought excellence to technology and innovation," as highlighted by the Lecture's Chair. The convergence of these technologies was going to accelerate the scientific method itself and the discoveries that could be made with it.

Dr. Assefa recalled that, at the end of 2021, NASA had launched the James Webb Space Telescope into space. The orbiting infrared observatory complemented and expanded the discoveries of the Hubble Space Telescope, with longer wavelength coverage and greatly improved sensitivity. Since July 2022, scientists had been receiving Webb's observations. "The telescope itself was already a testament to human ingenuity and scientific advancement," and its images helped humanity realize how small its planet is and how big its challenges are—COVID-19, for one, which claimed the lives of over 6.5 million people, with financial losses in the trillion.

Through such challenges, however, humanity had learned unique lessons, such as to rely on science and make the most of data-driven diagnostics, to foster collaboration when it came to finance and logistics, and to share knowledge and make it accessible.

In addition to science and computing, also partnerships were central to tackle today's challenges, the major ones being future pandemics, climate change, the food supply chain, and financial inclusion. Dr. Assefa focused mainly on the climate crisis.

Recalling the 2022 United Nations Climate Change Conference (COP 27), concluded a few days earlier, Assefa said that, by now we know, without a doubt, that climate change is caused and aggravated by human activity, and now the discussion is what we can do to address it. He underlined that technology was central for both mitigation and adaptation strategies.

He shared some concrete examples on how to use science and computing to address word challenges: IBM researchers, for instance, collaborated with other scientists to develop a new way to predict and detect floods; used satellite imagery and artificial intelligence (AI) to forecast flooding patterns with 98 per cent accuracy, which was important to inform emergency response, calculate damages and save lives; harnessed the power of AI to study health effects of heat waves and climate change, and to calculate natural carbon sequestration, as well as to study carbon capture, utilization and conversion.

The very innovations needed to address these challenges could also drive economic growth. IBM Research, with its 75 years' experience, 21 locations around the world, and a team of 3,000 scientists, was a good example of how to use innovation to tackle major problems: IBM researchers worked non-stop at what they call "What's next?" namely, AI, nanotechnology and quantum computing. And in all the three areas, IBM had been pushing frontiers.

Accessibility to science through global partnerships was equally critical. Ultimately, it was not only about technology, but also about the extent to which technology was accessible to advance innovation and solve problems.

Open sourcing, or having the source code of a software freely available for possible modification and redistribution, could accelerate innovation. Some IBM resources had been open-sourced this very year and others were in the pipeline.

The take-home message was that, while we live in a small planet and we must face big challenges, we also have very valid instruments to overcome them.

Keynote Lecture 2

Title: Circadian Rhythms, Gene Expression and Cell-Type Specificity of the Adult Fly Brain

Speaker: Prof. Michael ROSBASH, Nobel Laureate, Professor of Biology and Peter Gruber Professor of Neuroscience, Brandeis University, USA

Chair: Prof. YANG Wei, TWAS Treasurer

Rapporteuse: Dr. Munkhtsetseg TSEDNEE, TWAS Young Affiliate (Mongolia)

A neuroscientist and chronobiologist at Brandeis University, USA, Michael Rosbash was one of the recipients of the 2017 Nobel Prize in Physiology or Medicine for discoveries of molecular mechanisms that control circadian rhythms—the ways that biological organisms align their lives with the 24-hour cycle from day to night, governing important processes such as sleep.

In the first part of the lecture subtitled “Truth in science, evidence-based decision, and inspiring young minds,” Prof. Rosbash shared his insightful views and guidance on how curiosity and doubt could be the drivers for basic sciences. The science ecosystem, including publications and vigorous public debate, rather than scientists themselves, kept science more honest than other areas of society.

In addition, internationalism—no national borders—in science was essential in helping reduce parochial behaviours, subjecting science to higher and more objective standards. Prof. Rosbash highlighted that to be a successful scientist, one needed to be original and find new angles of looking at things.

He further shared his guidance on how to train and mentor students and postdocs to become successful scientists with the general mentoring rule “Do the right thing” as the main guideline. Mentorship, like parenting and leading by truth and respect, could be the way of preparing future scientists and future citizens. As an example of internationalism, he mentioned his former 15 Chinese PhD students and postdocs, including his first and third PhD students, Professor Yu Qiang and Dr. Xiaoling Liao, for their successful contributions to his laboratory research and intercultural learning.

In the second part of the lecture, the key message delivered by Prof. Rosbash was that humans can learn a lot from the mind of a simple fruit fly. Research on these insects had already facilitated progress in the understanding of the internal clocks that govern so much of mammals' lives, and therefore also human physiology.

Prof. Rosbash presented his research on the circadian rhythms of the fruit fly *Drosophila melanogaster* brain by introducing some of the recent discoveries of his laboratory on circadian neurons. He outlined the general properties of the circadian rhythm—a core circadian transcriptional feedback loop of conserved clock genes. With the use of sophisticated new techniques—FlyBox experimental setup and the single-cell RNA sequencing method developed by his former and current postdocs, Prof. Fang Guo and Dr. Dylan Ma—his research team had identified, in the adult fly brain, a large number of clock neuron types with 2–3 neurons/cell type and cell-specific expression of communication molecule messenger RNAs, neuropeptides and cell surface molecules.

Prof. Rosbash also shared his team's extended studies on comparative assays of clock neurons and dopaminergic neurons, concluding that there were common features between the two, with the general roles of communication molecules in the adult fly brain.

During the question-and-answer session, Prof. Rosbash provided detailed answers to the questions asked by participants. Some of the questions focused on the potential applications of research on circadian genes; the evolutionary perspective to reflect on why the tiny brain of a fruit fly needed so many neuropeptides similar to circadian behaviours; and whether the circadian rhythms affect differently males and females.

Tuesday, 22 November

Ministerial Session

Title: Basic Sciences for Evidence-Based Decision-Making and Sustainable Development in the Global South

Co-Chairs: Dr. Shamila NAIR-BEDOUELLE, UNESCO Assistant Director-General for Natural Sciences, and

Prof. HOU Jianguo, President of the Chinese Academy of Sciences (CAS

Speakers: Paulo ALVIM, Minister of Science, Technology and Innovation, Brazil

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Moussa BALDE, Minister of Higher Education, Research and Innovation, Senegal

Adham BIN BABA, Minister of Science, Technology and Innovation represented by Haji Aminuddin BIN HASSIM, Secretary-General of the Ministry of Science, Technology and Innovation, Malaysia.

Maia do Rosário BRAGANÇA, Minister of Higher Education, Science, Technology and Innovation, Angola.

Dr. Munir M. Eldesouki, President, King Abdulaziz City for Science and Technology, Saudi Arabia

Emmanuel "Blade" NZIMANDE, Minister of Higher Education, Science and Innovation, South Africa.

Nicola TODARO MARESCOTTI, Minister Plenipotentiary, on behalf of Her Excellency Anna Maria BERNINI, Minister of University and Research

Rapporteuses: Prof. Etotépé SOGBOHOSSOU, TWAS Young Affiliate (Benin), and

Sena GALAZZI, Associate Programme Manager of the Organization for Women in Science for the Developing World

In his introductory remarks, the President of the Chinese Academy of Sciences (CAS) Prof. **HOU Jianguo**, addressed the importance of basic sciences as the foundation of science and technology innovation. Basic sciences were not only an important way for human beings to explore the world and expand knowledge boundaries, but also a driving force for economic and social development.

In her opening remarks, UNESCO Assistant Director-General for Natural Sciences Dr. **Shamila NAIR-BEDOUELLE** said that basic sciences play a vital role in improving the quality of life around the world, as they address challenges ranging from climate disruptions to infectious diseases. Only new knowledge could help tackling multiple crises that affected the planet Earth, and this was the reason why UNESCO was leading the International Year of Basic Sciences for Sustainable Development until 2023. Basic sciences and basic research still lacked resources, yet humanity’s greatest discoveries were brought about by curiosity. Basic research and social transformation were paving the way to better interconnected lives. So, developing capacities in basic sciences was more important than ever.

Among the main points discussed featured the importance of basic sciences in addressing the different challenges the world faces today; the development of online education platforms to improve education in basic sciences; gender representation in science; and the importance of raising awareness on the role of basic sciences and research.

Interesting countries' initiatives included an annual celebration of women in science in South Africa; the creation of a virtual university in Senegal; the elaboration of national strategies integrating entrepreneurship, training in basic sciences and sustainability in Brazil, Senegal and South Africa; and the teaching of science in secondary schools in Angola.

Minister of Science, Technology and Innovation of **Brazil Paulo ALVIM** underlined the strong connection between basic sciences and sustainable development, and his country's commitment to that connection, which translated into Brazil's co-sponsoring the resolution that proclaimed 2022 as the International Year of Basic Sciences for Sustainable Development. The Federal Constitution of Brazil clearly stated that basic scientific research was a priority. As such, for Brazilians it was a constitutional matter. As a consequence, partnerships with science and technology institutions and stakeholders were also a national priority, which translated into diversifying and consolidating basic research capabilities through the provision of research grants, and investments in research infrastructure.

Minister of Higher Education, Research and Innovation of **Senegal Moussa BALDE** underlined that his country was looking to global partners, and that the President of Senegal had put in place a national policy focused on human capital sustainable development; a presidential council on higher education and science and technology; and a series of ambitious initiatives aiming to act as vectors for sustainable development, access to higher education and research, technical and vocational training. He also provided details on a number of other projects and presidential decisions aiming at enhancing networks of higher education institutes, and creating resources and opportunities for space and digital technologies, including the acquisition of a super computer and a microsatellite launch, scheduled for 2023.

Minister of Science, Technology and Innovation of **Malaysia Adham BIN BABA** was represented by the Secretary-General of the Ministry **Haji Aminuddin BIN HASSIM**, who underlined the importance of implementing solidarity among nations through science diplomacy. It was also essential to encourage enquiry-based science, teaching and learning across educational levels, from preschools to tertiary levels, aiming to produce a generation of innovative thinkers and doers.

His Ministry was implementing a host of initiatives—including a national action plan—to champion evidence-based policy on matters related to science, technology and innovation. A key aspect of this action plan was to ensure people-centric, nature-based and value-driven solutions, and in so doing Malaysia was keen to identify opportunities for new collaborations.

Minister of Higher Education, Science, Technology and Innovation of **Angola Maria do Rosário BRAGANÇA** underlined how large part of the results of applied research rested on basic sciences, which helped solve real problems affecting societies worldwide. Basic sciences, in fact, provided essential means to face global challenges linked to Sustainable Development Goals, especially universal access to food and health coverage. Angola was taking significant steps to improve basic sciences, especially through her Ministry. Angola was also addressing gender inequality, and thus implementing ambitious scholarships programmes focused on Sustainable Development Goals 4 and 5, on quality education and gender equality, respectively.

The President of the King Abdulaziz City for Science and Technology of **Saudi Arabia, Munir M. Eldesouki** highlighted that his country was an innovation-driven nation that had achieved a significant development in the last years. Global innovation studies had placed high in scientific rankings: Saudi Arabia had gained the fifteenth place in the global innovation index, and was ranked among the top 10 in a few of sub-indicators. There had been a surge in scientific publications, both in terms of quantity and quality, which made the country rank n. 1 in the Middle East and n. 25 globally. Eldesouki connected this advancement to Saudi Arabia’s great investments in basic research in the past years, whereby 50 per cent of public research-and-development funding was devoted to basic sciences. Now the country was shifting towards more applied and tech-driven research after years of focusing on basic sciences.

Minister of Higher Education, Science and Innovation of **South Africa Emmanuel "Blade" NZIMANDE** explained that South Africa fully supported activities related to basic sciences, for example through the work of TWAS Regional Partner in South Africa, TWAS SAREP, which was hosted by the Academy of Science of South Africa in Pretoria. His country had finalised a new science-technology-and-innovation digital plan and was working on a new white paper on inclusive development. Prior to the Conference, TWAS SAREP was involved in several important initiatives led by UNESCO-TWAS. He underlined the importance of basic sciences for sustainable development, and mentioned the World Science Forum, hosted in South Africa in December (2022), and focused on "Science for Social Justice."

Minister Plenipotentiary **Nicola TODARO MARESCOTTI of Italy**, speaking on behalf of **Anna Maria BERNINI**, Minister of University and Research, expressed his pride in being the host country of the Academy, and underlined the Italian Government's strong support to TWAS and to the Abdus Salam International Centre for Theoretical Physics (ICTP), which was a confirmation of the Italian commitment to cooperation and the advancement of science in developing countries. The Conference was a great opportunity to identify areas of possible cooperation, particularly in addressing the impact of the climate crisis, which should lead to decouple growth and degradation. Basic sciences and basic research played a central role to achieve the Sustainable Development Goals, and cooperation was needed to achieve green and blue economies. Developing a new generation of scientists was therefore a priority, and

TWAS could play a paramount role in creating and nurturing a new generation of committed students and scientists.

Symposium 1

Title: Basic Sciences: Challenges and Sustainable Development

Conveners: Prof. Merieme CHADID, Chair of United Nations Scientific Board, UNESCO International Basic Sciences Programme and

Prof. Luiz DAVIDOVICH, TWAS Secretary-General

Facilitator: Dr. Max PAOLI, TWAS Programme Coordinator

Rapporteuse: Dr. Sabrina ELIAS, TWAS Young Affiliate (Bangladesh)

Speakers: Prof. HOU Jianguo, President of Chinese Academy of Sciences, China, on "Chemistry to Empower a Sustainable World"

Prof. Agnes BINAGWAHO, Vice-Chancellor, University of Global Health Equity, Rwanda, on "Improving Health Science Education to advance global health research in LMICS[1]"

Prof. Jagannatha K. RAO, Director, Institute for Scientific Research and Technology Services, Panama, on "Basic Sciences and Sustainable Goals: Challenges and Excitements"

Prof. Ingrid DAUBECHIES, James B. Duke Distinguished Professor of Mathematics and Electrical and Computer Engineering, USA, on "Challenges and Sustainable Development: Mathematics"

Prof. LU Gaoqing (Max), President and Vice-Chancellor, University of Surrey, UK, on "Sustainability Leadership in a World Class University"

Prof. Anthony CLAYTON, Professor of Caribbean Sustainable Development, University of the West Indies, Jamaica, on "Evidence-based decision-making and sustainable development in developing countries"

Part I

[1] Low- and middle-income countries.

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Prof. **Merieme CHADID** opened the session recalling her experience as an explorer in expeditions to Antarctica, and her learning how science could impact our world. The session focused on how we can strengthen bond between the Sustainable Developments Goals and basic sciences, since basic sciences also enabled the ability to develop policies.

Prof. HOU Jianguo, President of Chinese Academy of Sciences, speaking on "Chemistry to Empower a Sustainable World," focused on the vital role that basic sciences played in sustainable development, and how chemical research could boost sustainable development particularly in developing countries.

The common challenges that the countries of the world were facing were experienced more severely by developing countries.

Chemistry dealt with matter transformation and functions, and with energy conversion and storage, and Prof. HOU provided many examples of how impactful chemical research from the Chinese Academy of Sciences (CAS) could contribute to attain the Sustainable Development Goals, and recommended many relevant actions.

Benefiting from chemistry, human beings had produced fertilizers and pesticides to increase the food supply; had developed water treatments, e.g., desalination, to bring forth safe drinking water; had developed new medicines, diagnostic tools and treatments for better health; had discovered new reactions and developed new processes for the clean use of energy; and had invented environment-friendly material and land pollution-control technologies to help the environment.

Prof. HOU then provided an overview of the chemical research achievements of CAS. The Academy had 1,100 full professors covering various sub-disciplines of chemistry. Milestones the Academy had achieved included the synthesis of crystalline bovine insulin, and the production of synthetic rubber. In 2021, chemistry-related papers from CAS had accounted for about 4.86 per cent of the global production, and CAS ranked n. 1 globally in terms of highly cited papers and highly cited researchers.

In terms of the SDGs, CAS had kept working on green energy, applying chemistry to ensuring food security, for instance, through the conversion of nitrogen and carbon dioxide into organic molecules; and seeking lower and greener energy consumption methods. CAS researchers had opened a new chapter in the field of developing new nitrogen fixation methods without ammonia synthesis. Photosynthesis was the source of our food: synthesizing glucose and carbohydrate from carbon dioxide (CO_2) and water (H_2O) by electrolysis and biosynthesis, and synthesizing starch from CO_2 and hydrogen independent of photosynthesis offered new routes of supplying food.

Chemistry helped achieve the goal of carbon peak and carbon neutrality by developing new technologies for material and energy supply without using fossil resources. Chinese researchers had come forth with 'green carbon resources' for recycling carbon resources, and 'green chemistry'. They had also converted solar energy into other forms of energy, thus achieving carbon peak and carbon neutrality.

Prof. HOU also emphasized the efficient conversion of solar energy, and the thermochemical water splitting for hydrogen production.

On environmental pollution—an issue particularly critical for developing countries—Chinese researchers had identified pollutants' sources in order to be able to treat pollutants. Processes like photocatalysis, electrodialysis and nanofiltration, for instance, could provide developing countries with water treatment equipment to produce clean water.

On air pollution, atmospheric haze chemistry had been largely supporting China's pollution control actions, and monitoring had shown that between 2013 and 2022 there had been a dramatic improvement in the air quality in China, comparable to the improvement experienced in the developed countries in 30 years. So, China could become a model for other developing countries.

As for plastic pollution, conversion of polyethylene waste into gasoline, under mild and controlled conditions, could be one way to tackle it. Another way was to produced biodegradable plastic.

Chemistry also contributed to the efficient utilization of resources: chemists, in fact, were striving to improve the efficiency of separation, purification and recycling of mineral resources.

In conclusion, Prof. HOU shared his own perspective on chemistry: chemistry, along with the other basic sciences, would dramatically improve our view of nature, improve our toolset to build a better world, and provide material security for human development.

Speaking on "Improving Health Science Education to Advance Global Health Research in LMICS," Prof. **Agnes BINAGWAHO** pointed out that 85 per cent of the global population lived in low- and middle-income countries and carried 90 per cent of the burden of diseases. Yet, they produced 20 per cent of publications, which highlighted that research outputs and efforts were unequal when compared with the threat of diseases suffered by people living in low- and middle-income countries. Further, only 6.5 per cent of publications in general medical journals had as co-authors scientists from those countries in which much of the world population lived.

Similar challenges were faced in health education. In fact, where were global health programme developed? How much did they cost and who could afford them? Who was attending such courses and which communities were benefiting from them? A study published by the *BMJ* showed that most of these programmes were in high-income countries and inaccessible to most.

Prof. BINAGWAHO then focused on the challenges faced in Africa and how best to solve them by promoting better health science education. The health workforce in the continent faced challenges that were both qualitative and quantitative. Sub-Saharan Africa, for example, carried 24 per cent of the global disease burden, but only 34 per cent of the global health workforce. Of the 74 per cent of deaths provoked by non-communicable diseases, 77 per cent occured in Africa. Most of educated health professional in Africa were lost to high-income countries, while 40 per cent of the people working in health care in Africa lacked standardized health education. Moreover, the health sector also suffered from gender inequity, whereby only 28 per cent of physicians in Africa were female, and only 25 per cent of females globally held leadership positions.

To achieve global health coverage by 2030, Africa would need a 6.1 million-strong workforce, which was higher than the rest of the world combined, with Europe and Central Asia together needing 1.2 million, and South Asia 3.2 million. Various factors contributed to this shortage, one of them being the shortage of medical schools. Africa counted 168 medical schools, whereas the USA had 173 and India 304. To address such shortage, the shortage of teachers must be addressed.

COVID-19 had impacted health education, as well as other education sectors, globally. Further, there has been a lack of preparation to face such a pandemic, the lockdown had disrupted both education and clinical training, and only 38.5 per cent of Africa's higher institutions had had access to e-learning. The pandemic had also an impact on funding and partnerships for universities.

Universities could play a key role in achieving the Sustainable Development Goals (SDGs), providing examples on Goal 17, on partnerships; Goal 4, on quality education; and Goal 3, on good health, while underlining the need to tackle all the 17 Goals and investigating the social determinants of health through education.

On Goal 17, Prof. BINAGWAHO highlighted the need to increase partnerships for Africa among universities, research institutes, governments and non-governmental organizations. It was also critical to strengthen such partnerships in order to be able to face new crises, while being able to help vulnerable communities and ensure equity. Lastly, South-South partnerships needed to be increase in order to challenge both western supremacy and the North-South paradigm in high education.

An impactful example had been a Rwanda-led programme for the training in health sciences of teachers and students, launched in 2012, which had started with a partnership with

23 institutions of higher education of the US, later joined also by institutions of Switzerland and Belgium. The programme had led to an increase of healthcare professionals.

To achieve such objectives, however, it was critical to ascertain the social accountability and impact of institutions using the *The Times Higher Education* Impact Rankings performance tables that assessed universities against the SDGs, and to find a ranking system that could be applied to African universities.

Prof. **Jagannatha K. RAO**, Director of the Institute for Scientific Research and Technology Services of Panama, speaking on "Basic Sciences and Sustainable Goals: Challenges and Excitements," said that the Sustainable Development Goals were transforming the world by changing the life of people.

It was critical to build human capacity by 2030 to make people technologically and individually strong, helping them develop a scientific mindset that can contribute to the growth of different sectors. Innovation started at the school level. Building fundamental sciences was a very crucial point, for which building a science-based education was crucial. Globalization was also crucial in that it brought rich and poor countries together. So, for students it was important to "know the world," to understand the gaps between rich and poor. It was equally critical to provide students with multiple skills, with interdisciplinarity, while, at the same time fostering gender equality.

While aiming at achieving such objectives, the technology and innovation was essential in preparing students to be able to solve local, national and global challenges. And sustainability should be part of such endeavours, and part of the long-term vision. A harmonious development should be envisioned, nurturing women and men to become good leaders, so that the gap between rich and poor could be filled.

As an example, Prof. RAO mentioned the high number of people affected by mental disorders, which would reach 50 million by 2050. To tackle such situation, it was critical to develop skills of different kinds: medical, scientific and social. That is why, basic sciences should be leading to technology and innovation, and ultimately to sustainable development. Doing so would help create a roadmap to address global challenges.

With such a vision in mind, the role of TWAS in bringing together scientific capacity from all over the world was crucial, as the Academy contributed greatly to building networks that could find global solutions.

Part II

Introducing the second part of the symposium, TWAS Secretary-General Prof. **Luiz DAVIDOVICH** underlined that basic sciences played a big role in tackling the challenges the world was facing, in particular in reducing inequalities.

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Prof. **Ingrid DAUBECHIES**, James B. Duke Distinguished Professor of Mathematics and Electrical and Computer Engineering at Duke University, in the US, started her presentation on "Challenges and Sustainable Development: Mathematics" defining mathematics as the science of patterns of reasoning. Mathematics was also essential for natural sciences (physics, chemistry and geosciences), as well as for engineering, medicine and environmental sciences (e.g., the equations that govern the weather), ecological studies and epidemiology, among others. Mathematics provided the language and concepts needed for such descriptions of the world; it allowed to study sophisticated models showing what was approximate and what essential to keep for valid predictions; it was increasingly important for computational techniques and algorithms, and for data analysis.

The link with sustainable development was that, in order to study solutions to the current global challenges, every country needed scientists, engineers and data analysts attuned to that country's challenges, embedded in and completely aware of the local situations and the local culture. To provide the necessary training to those scientists, engineers and data analysts, it was essential to have home-grown mathematicians. This meant to have mechanisms in place through which it was possible to identify mathematical talents in the local population to be trained and allow to flourish locally.

Inspired by TWAS commitment to develop fellowship programmes in the global South, the International Mathematical Union had started Breakout Graduate Fellowships and Graduate Research Assistantships to grow mathematical talents in their own countries. While such initiatives were laudable, much more needed to be done. And the challenge to nurture mathematical talents deeply linked to their own culture was big not only in the global South, but also in countries like the United States, where there were underserved communities in need of input and energy from the mathematical community. To do so, vibrant mathematics departments were needed.

Prof. **LU Gaoqing (Max)**, President and Vice-Chancellor of the University of Surrey, in the UK, talking on "Sustainability Leadership in a World Class University," said that a word class university would produce good graduates that would do great things, thus making a difference. Such a university also made a social and environmental impact. The high quality of such institutions would be reflected in their receiving high rankings or public recognition, which, in turn, would leading to establish their reputation. This is what Prof. LU defined the 'virtuous cycle' of world class universities.

The University of Surrey was such an institution with dual excellence in both teaching and research, as well as a high impact in terms of sustainability. Ninety-six per cent of the University students found an employment within six months from graduation, which was why it had became the university of the year for graduates' employment in 2022. The University ranked fifty-fifth in the world for its contribution to the achievement of the SDGs, in particular to the achievement of Goal 6 on clean water.

The University had a high number of research centres working in different areas, including clean energy and water, sustainable prosperity, sustainable living, food and nutrition, sustainable tourism and transport. And in all those areas the University of Surrey collaborated with many industrial partners around the world for research and research training.

The University of Surrey was home to the first world smart satellite. The Surrey Space Centre had launched 47 space missions, and was a major supplier and manufacturer of 22 satellites used for the European GPS system, but also for predicting natural disasters and applied in agriculture. The University had also made a breakthrough in space science in 2018 by launching the first satellite removing space debris, thus greatly contributing to space sustainability. Recently, the University had launched its Institute for Sustainability bringing together experts from social sciences, science and engineering, and medical science to develop solutions to sustainable living and sustainable infrastructure, at the nexus of food, water and carbon.

The world was facing ten main challenges and many institutions were working on finding solutions to them, particularly the top three: energy, climate, and food. Prof. LU's expertise included hydrogen production and safe storage. Hydrogen was very promising for its zero-impact on the environment. By 2070, hydrogen would become a significant component in the energy mix, with the main sector using it being shipping, aviation and road transport.

Green hydrogen was hydrogen produced from renewable sources: solar, wind and water electrolysis. The current production, however, was still quite small, with bigger numbers for the production of grey hydrogen, namely hydrogen produced from non-green sources. The hydrogen was then stored in compressed tanks before being utilized for fuel cells.

Prof. HOU also shared a graph showing how the direct conversion of solar energy into hydrogen would be possible in the future, through a process called photocatalysis. While the solar-to-hydrogen efficiency was quite high, it was still very costly at the moment. Also, at the moment, the solar-to-hydrogen efficiency was low in costs but also in efficiency. That was why, more research was needed, and there was also a need to develop more and better photocatalysts, namely catalysts with better crystallinity and stronger light absorption capacity, which was exactly the purpose of Prof. LOU's research. Increasing the solar-to-hydrogen efficiency from 1 to 10 per cent was not easy.

Further, an artificial leaf could be produced to convert solar energy into hydrogen.

Prof. **Anthony CLAYTON**, Professor of Caribbean Sustainable Development at the University of the West Indies, Jamaica, speaking on "Evidence-based decision-making and sustainable development in developing countries," pointed out that among the challenges to sustainable development in developing countries was the different approach that politicians and scientists might have. Many politicians were inclined to short-term thinking, focused on development that would give them political advantage, and that favoured personal profit over national interests. The discussions on climate change, for instance, often focused on compensation rather than on moving people and infrastructures out of harm's way.

The scientific community too had its limitations, such as thinking naively that people acted on clear, facts-based arguments, in all evidence of the contrary, and without understanding the limited role of scientific evidence in political decision-making, without engaging in complex social and political trade-offs, and without valuing the contribution of the social sciences.

A better approach could be to focus on solutions that won on a number of dimensions simultaneously: politicians needed to see a viable transition path to a better future, choosing options that offered investment opportunities rather than high economic costs. An additional value for politicians would be if such stances could also bring possible electoral advantages.

On its side, the scientific community should be prepared to engage with complex social and political trade-offs and contribute to finding viable transition strategies. And, in this regard, an interdisciplinary approach was absolutely essential: politicians could possibly use only one discipline, as their job by nature involved making interdisciplinary decisions.

A solution-oriented approach was therefore critical, and it usually involved a clear statement of the problem, a focus on solutions, and the identification of win-win options.

An example: by 2050, demographic growth would add another 2.5 billion people, and material consumption by cities would grow from 40 billion tonnes (2010) to 90 billion tonnes per year, and 60 per cent more food would be needed, which would be a particular challenge, because 60 per cent of humanity would live in water-stressed regions. By the end of the century, the population of Africa will be 40 per cent of the total world population, mostly living in coastal cities and being extremely vulnerable to climate change.

These figures provided a very clear direction: it was critical to increase the efficiency in producing food, managing water and decarbonizing the economy as quickly as possible. Currently, the world was not on such a trajectory: by 2050, about 570 cites would be partially or totally flooded, and about 1.4 billion people might have to relocate. This number, added to the one of the urban population growth—2.5 billion—, would mean that a total of 3.9 billion new homes would need to be built, 50 per cent in Asia, 25 per cent in Africa and 25 per cent distributed in the West.

So, we had to start thinking about how those future cities would look like, with structures that integrate food, water and air quality control, cities that would be able to adjust in case of flooding, e.g., with amphibious houses, and raise above the level of the floods. Building that were energy-efficient and had solar panelled roofs, and with much lower construction costs and much shorter construction time.

Further, thinking of the extra food that would be needed, there were already prototypes in the Netherland showing how to refocus agriculture by maximizing productivity and minimizing environmental costs. In such agriculture units, since 2000, water use had been reduced by 90 per cent, pesticide use in greenhouses by 100 per cent, and antibiotics by 60 per cent.

Looking at the future, humanity could come to two quite opposite outcomes. The positive one could be achieved by taking the right political decision overcoming the challenges expressed at the beginning of the presentation.

Question-and-Answer Session:

Answering to a question on education for sustainable development, **Prof. Lu** explained that the basic understanding of issues like climate change, biodiversity, should be common to all undergraduate curricula.

Universities could start new degree programmes. The University of Surrey, for instance, had started a new degree on sustainable development to educate the next generations not only to be aware but also to find solutions to those challenges.

On a question on mathematics, **Prof. Davidovich** mentioned that mathematicians, but also scientists in general, do science not only because it is useful, but also because they were very much motivated by the beauty of the discipline.

Answering to a question on the reception by politicians of the propositions exposed by **Prof. Clayton**, he commented that education was the very first step to take—social reengineering—introducing basic scientific concepts starting from primary schools and then developing and explaining them in secondary schools. It was a long-term strategy.

Regarding on how scientists talked to politicians, the former had been naive in the past. Politicians needed to have a clear narrative, going to them with solutions, making them realize that those solutions could not be taken in isolation, but rather that many factors came in place—sustainability, climate-resilience and the fight against corruptions. Politicians needed to be shown a credible, politically attractive vision they could believe in.

On the use of hydrogen and its transport, **Prof. Lu** said that solid state storage of hydrogen was possible and alos that hydrogen could be transported in liquid form transformed into ammonia.

On a question on how could basic sciences contribute to enhancing trust in science, **Prof. Clayton**, said that, due to the pandemic, in Jamaica, education had been interrupted for two years, as students could not go to school nor attend online. So, many children were two years behind in their education and are struggling to catch up. There was a massive amount of misinformation during the pandemic, so, in Jamaica only 25 per cent of the population was vaccinated. Basic scientific literacy/education was therefore essential across the entire communities. To such observations, **Prof. Lu** added that the basic science researching on mRNA-based vaccines had been going on for decades.

Thursday, 24 November

<u>TWAS-Abdus Salam Medal Lecture</u>

Title:	Exploring the Frontiers of Science with the Opening Up and Sharing of Mega-Science Facilities for the Benefit of Major Breakthroughs in Basic Science
Chair:	Prof. Mohamed HASSAN, TWAS President
Recipient:	Prof. BAI Chunli, TWAS Immediate Past President, President of the Alliance of International Science Organizations, and Honorary President of the Presidium of the Academic Divisions of the Chinese Academy of Sciences
Rapporteur:	Dr. Nihad ADNAN, TWAS Young Affiliate (Bangladesh)

In the lecture Prof. BAI delivered in accepting TWAS-Abdus Salam Medal, he said that the introduction of mega-science facilities (MSFs) had allowed the advancement of science and technology by making the exploration of the unknown world and the discover of the laws of nature easier, and they had enabled the realization of technological transformations. Moreover, MFCs had provided the foundation to making major breakthroughs, and solving major challenges to socioeconomic development and national security.

Mega-science facilities led to major scientific discoveries and to the advancement of academic disciplines. Having clear research objectives, several fields of applications and cutting-edge technologies, and requiring big investments, they were more likely to lead to new scientific discoveries.

Prof. BAI focused his talk on three main aspects.

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1. Mega-science facilities played a major role in promoting scientific research and innovations, especially in promoting breakthroughs in basic research.

The research and development of MSFs started in the United States before the Second World War through the Manhattan Project, under which a series of nuclear reactors and accelerators were developed, which, in their turn, contributed to US research in nuclear energy, nuclear physics and particle physics.

After the Second World War, the United States, the then-Soviet Union and other science-and-technology States started to implement major mega-science research initiatives, such as artificial satellite programmes, manned space programmes and the Apollo programme.

In the middle of the last century, the role of MSFs became bigger. In the twentieth century, 20 Nobel Laureates in physics had received the support of MSFs. Einstein pointed out that "the future of science is nothing but a continuous exploration into the macro- and micro-world." And MSFs significantly facilitated the expansion of scientific research into the macro-world, and promote deeper exploration of the micro-world.

At the macrosystem level, MSFs contributed to explore dark matter and dark energy, black holes, and the origin of the universe, of celestial body and of life. In April 2019, for example, the Event Horizon Telescope had released, in live broadcast, the first-ever image of a super-massive black hole, distant 55 million light-years from the Earth.

In December 2021, NASA had launched the James Webb Space Telescope to find first-born galaxies, study the evolution of galaxies and the formation of stars and planets, and measure the physical and chemical properties of planets.

At the microscopic level, MSFs contributed to study the standard model of elementary particles. Examples were the Large Hadron Collider, the world's largest particle physics accelerator with the highest energy range; Micius, the world's first quantum science satellite launched by the Chinese Academy of Sciences (CAS) in 2016; and the Beijing-Shanghai quantum secure communication backbones network, the world's first long-distance optical fibre quantum communications trunk line led by CAS in 2017.

2. Major mega-science infrastructure had become the focus for science and technology by the world science-and-technology-strong States.

MSFs had a big and lasting impact and were sophisticated in technology. The United States, for example, had developed MSFs of high performance, which were playing a big role in strengthening scientific and technological innovation, national security and the socioeconomic development of the country.

Mega-science facilities in the in the United States contributed to high-energy physic, nuclear physics, astronomy, nanobiotechnology, eco-environment and information technology. MSFs in Europe were keeping science and technology competitive, facilitated peace and cooperation among European countries, increased the rate of occupation in the technology field and were winning Europe a position of superiority in the global industrial chain.

3. China was committed to the development of mega-science facilities, and to their openness and knowledge-sharing in the hope of making contributions to the global science-and-technology progress.

So far, China had approved 57 major MSFs, among which 32 were in operation and 27 under development. Some of them were already ranked among the first such facilities. The Chinese Academy of Sciences was a trailblazer in the research and development of major science-and-technology basic research infrastructures, as well as in MSFs in China. It had built and operated 30 of those 57 facilities. Such facilities were open to cooperation with institutions and researchers of China and from abroad. CAS successfully developed and launched in 2015, the Wukong (DAMPE)—a dark matter particle explorer. CAS also built LHAASO, a large high-altitude air shower observatory, to unveil the century-old mystery of the origin of cosmic rays and their acceleration.

Further, FAST (also known as China sky eye), the world's largest single-dish radio telescope, had been voted one of China's top 10 scientific achievements in 2021. China had also built built EAST (also known as Chinese artificial sun), the world's first full superconducting experimental Tokamak fusion device, and, in March 2019, had signed an agreement to build SKA (Square Kilometre Array), which would be composed of about 2,500 dishes spread over Southern Africa and 1 million antennas distributed in Australia.

These achievements showed China's leading position in science and technology. In 2017, the "Beijing Fusion Declaration - Supporting Fusion Energy Development in China" was issued to support the construction of China's Fusion Engineering Test Reactor and develop the International Thermonuclear Experimental Reactor Project (ITER) in China. The project involved the United States, Japan, India, France, the Russian Federation and the Republic of Korea.

From 2 to 4 December 2019, the GSO 14[2] had been held in Shanghai, where Chinese representatives suggested sharing Chinese mega-science facilities in the GSO system for case studies, and proposed further cooperation among all such facilities in the world. It was the first time the event was held in Asia. There was already successful cooperation among

[2] The Group of Senior Officials (GSO) on global research infrastructures was established in 2008 at the first G8 Science Ministers' meeting to promote transnational access to global research infrastructures. Members include G7 countries, Brazil, Russian Federation, India, China and South Africa (BRICS), Australia, Mexico and the European Union.

research institutions. China, for example, was helping other developing countries, like Thailand, to develop mega-science facilities like the Siam Photon Source (SPS II), which would be the first fourth-generation synchrotron radiation facility in South-East Asia, as well as Thailand Tokamak (TT-1), which would be the first tokamak in South-East Asia. China was eager to help other countries develop MSFs.

<u>Symposium 3</u>

Title: Basic Sciences for the Sustainable Development Goals in China

Convener: Prof. YANG Wei, TWAS Treasurer

Rapporteur: Dr. Pablo Alberto BOLAÑOS-VILLEGAS, TWAS Alumnus (Costa Rica)

Speakers: Prof. HUANG Hefeng, Institute of Reproduction and Development, Fudan University, China, on "Early-life Health and the Burden of Adult Chronic Diseases"

Prof. ZHU Meifang, College of Materials Science and Engineering, Donghua University, China, on "Functional and Intelligent Fibre Materials for Sustainable Development"

Prof. LIU Ming, Frontier Institute of Chip Systems, Fudan University, China, on "Integrated Circuit for Information and Intelligent Era"

Prof. ZHANG Tao, Vice-President, Chinese Academy of Sciences, and Professor at the Dalian Institute of Chemical Physics, China, on "Single- Atom Catalysis: Progress, Opportunities and Challenges

Prof. DUAN Shumin, Dean of Zhejiang University, Faculty of Medicine and Pharmacy, China, on "A Brain Circuit Encoding a General Aggressive State"

Prof. PAN Jian-wei, Executive Vice-President, University of Science and Technology, China, on "Quantum Communication: Past and Present"

Prof. YANG Wei, TWAS Treasurer, said that the speakers—three women and three men, all TWAS Fellows—would provide their perspectives on the theme of the symposium.

Prof. HUANG Hefeng, a member of CAS, Chair Professor at the Institute of Reproduction and Development of Fudan University, and Chief Physician of the Women's Hospital at the

School of Medicine of Zheijiang University, made her presentation on “Early-life Health and the Burden of Adult Chronic Diseases.”

Some of the questions humans would like to find an answer to were: How much could human lifespan be extended? How long could humans live a long life in good health? What is the key to keeping healthy from early life to adulthood? To what extent are genetic variations and personal health linked?

COVID-19 had caused over 6.5 six million deaths. Three years of fighting the pandemic had reminded us that human lives and health remained critical in all scientific questions. In general, people were mostly concerned about infectious diseases, such as HIV/AIDS and tuberculosis, and chronic diseases, such as diabetes and hypertension.

Chronic diseases were defined as conditions lasting one year or longer, requiring ongoing medical attention, and limiting daily or other activities. Non-communicable diseases had become more and more concerning in most countries, especially in developing ones. Several of these chronic diseases were caused by maternal poor health that influenced neonatal development.

Being long-term, irreversible conditions, diabetes, hypertension, obesity and liver diseases caused a huge economic burden, even more than COVID-19, and reduced the quality of life. Living long and healthy was hard. It was important to understand that the health and nutritional environment experienced by foetuses and babies influenced people's health for the rest of their lives.

The idea of the Developmental Origins of Health and Disease (DOHaD) was first put forward by Prof. David J.P. Barker (1938–2013). The work by Prof. Huang had shown that intrauterine/pregestational hyperglycaemia might affect mice babies, as the process was controlled by imprinted genes. This meant that transgenerational glucose intolerance was caused by epigenetic intergenerational alterations regulated by the TETC methylase, coded by the TET3 gene in several target genes, such as Gck and Gna11*,* which regulated nutritional management in early life (the first 1,000 days), thus having a significant impact on non-communicable diseases. The World Health Organization global nutrition targets, to be achieved by 2025, targeted in fact those first 1,000 days of life.

Communities, families and mothers determined the health of foetuses during pregnancy. That was why, Canada, China, India and South Africa had launched the Healthy Life Trajectories Inititiave (HeLTI), in cooperation with the World Health Organization, to monitor the health of pregnant women, in particular their adiposity and glucose levels. This implied that parents had to live healthy lives for children not to develop obesity or diabetes.

In the future, molecular medicine might assist babies and adults in diagnosing the risk of developing chronic diseases. A reasonable target would be a reduction by 10 per cent in the development of these diseases through early genetic testing. Such genetic testing could reduce, for example, by at least 20 per cent the number of deaths by cancer. Genetic and genome databases were being created in China, but were already common in developed countries, such as the UK.

Prof. Huang concluded her presentation talking about personalized and precision medicine (PPM), which could reduce considerably the impact of chronic diseases.

Answering to a question on the current situation of obesity among children in China, Prof. Huang said that obesity had increased to the level of an epidemic, often accompanied by hypertension, unbalanced glucose levels, poor cognitive functions, poor academic performance and poor emotional development. It was an urgent challenge to be tackled all over the world, not only in China.

Hypoglycemia was related to genetic markers, so interventions must take place at the tenth gestational week, and, later on, testing must be done to the newborn as well.

Prof. ZHU Meifang, College of Materials Science and Engineering of Donghua University, speaking on “Functional and Intelligent Fibre Materials for Sustainable Development,” said that such materials were linked to human health and happiness.

In 1664, it was first theorized that it was possible to manufacture artificial fibres. The first artificial fibre was created in 1938. China went, in 40 years, from zero to manufacturing 70 per cent of world’s output in chemical fibres, which, in 2021, amounted to at 65 million tons. The future would belong to hybrid layered materials, usually consisting of an organic and and inorganic component that might include nanotubes.

Dr. Linus Pauling (1901–1994), whose fame is linked to his research into the formation of chemical bonds, for which he was awarded the Nobel Prize in 1954, put forward the concept of orbital hybridization for the formation of such bonds. This concept was being applied to the functional assembly of structural hybrids in clothing fibres, such as in the combination of functional PET and antibacterial fibres made of copper and spun together. Copper nanoparticles are assembled and hybridized *in situ* and then disperse. This process is 99 per cent effective in the prevention of bacterial growth. China had scaled up the production of multi-functional fibres, with factories in Zhejiang province, for example, where the Hengyi Co. Ltd produced 150,000 tons per year of functional spun. Functional fibres needed to be smart and green, so, multidisciplinary collaborations were necessary. A possible future application of such fibres could be to erect buildings on the Moon.

Green raw materials and low carbonization processing were needed to ensure sustainability in the future. China had gone from the ancient Silk Road to the The Belt and Road Initiative adopted by the Chinese Government in 2013, to invest in several countries and international organizations. Prof. ZHU had established collaborations with Egypt, Hungary and Israel. Further, 18 students from Pakistan, Uganda, Kenya, Bangladesh, the Sudan and Iran had graduated through the Belt and Road international education programme. She had recently become the editor of the Springer journal *Advanced Fiber Materials*.

In answer to a question on the pollution derived from nanoplastic, Prof. Huang said that efforts were being made in China to make materials recyclable.

Prof. **LIU Ming**, of the Frontier Institute of Chip Systems of Fudan University, speaking on "Integrated Circuit for Information and Intelligent Era," said that solid state devices, such as vacuums and transistors, were great inventions that allowed fast communications and great savings in energy. Later came metal oxide semiconductors that allowed the assembly of very small and very dense integrated circuits in computers, such as those by Intel and NVIDIA.

Miniaturization, however, caused heavy leaking of current and increases power consumption, which was a challenge. That was why, new materials, such as germanium-silicon hybrids, were needed. Nanosheets were critical for creating new and smaller computer chips with the help of UV-light lithography. This was a new technology for etching the surface of chips: it used extreme ultraviolet light (E-UV) at 13.5 nm wavelength with the numerical aperture of the lens that released the beam of light increased up to 1.36 by immersion. Semiconductors might become a 1 trillion-dollar industry by 2030 and allow for the growth of other technologies such as artificial intelligence, neuromorphic computing and computing-in-memory, which might bring about huge performance gains.

Answering a question on how to build integrated circuits for the future, Prof. LIU said that more investments in basic research were essential, along with increased investment in industrial development.

Prof. **ZHANG Tao**, Vice-President of the Chinese Academy of Sciences, and Professor at the Dalian Institute of Chemical Physics, speaking on "Single- Atom Catalysis: Progress, Opportunities and Challenges," said that catalysis is the increase or gain in the speed of a chemical reaction by using a chemical that is not directly consumed by said reaction.

Breaking an energy barrier, catalysts saved energy. First Jöns Jakob Berzelius (1779–1848) and later on Wilhelm Ostwald (1853–1932) described this phenomenon. Catalysts were used in the refinement of oil, in cars, in the altitude controls of aircraft and in fuel cells.

The latest generation of catalysts were very thin, so thin that the catalyst was not in contact with other atoms in a mixture but was suspended in a matrix called single-atom suspension.

Each atom spaced out far away from each other. This was a concept put forth by Prof. Zhang himself, who, in 2011, also co-authored a paper on the subjected published in *Nature Chemistry* and titled: "Single-atom catalysis of CO oxidation using Pt_1/FeO_x.

In single-atom catalysis, the core atoms of the catalysts were not in contact, but were able to interact with each other. Catalysts might be metals and non-metals. The matrix was a thin organic polymer, usually very thin, measuring 5 nm. And the suspension could be very stable, thanks to strong covalent interactions, especially in bonds between gold and oxygen.

Industrial applications of these new catalysts existed in the synthesis of propanol, a common solvent in the chemical industry, and in the refinement of shale gas deposits. New studies would be possible thanks to new facilities such as the fourth-generation synchrotron light source High Energy Photon Source in Beijing.

Prof. **DUAN Shumin**, Dean of Zhejiang University, Faculty of Medicine and Pharmacy, speaking on “A Brain Circuit Encoding a General Aggressive State,” said that aggression was a common behaviour linked to survival. Pathological aggression, however, was a psychiatric disorder that could not be controlled, caused serious social problems, could be triggered for no reason, and lacked effective therapies of intervention and remediation.

To treat pathological aggression, it was necessary to understand that the brain is made up of millions of neuron cells that form synapses and complex circuits. The activity of such circuits was controlled by molecules. A normal brain counted more than 100 billion neurons. So, behaviours depend on neuron circuits that are exceptionally large.

One of the ways to study aggression—known as optogenetic activation—was to use light in rat brains to stimulate specific circuits. Usually, a fluorescent chemical dye, such as DIO-mCherry, was used.

Several types of aggression were observed in rats (stereotyped aggression), such as male-to-male aggression, female-to-male aggression, predatory aggression to catch edible prey, defensive aggression, and aggression against baby mice by males (infanticide). Male aggression was quite common; usually males attacked intruders, but also females attacked intruders to protect their babies.

In mice, it was discovered that a brain region called posterior substantia innominate (pSI), and larger than the amygdaloid nucleus, controlled all types of aggression, including rage-like attacks, single and multiple. Its activation depended on the flow of calcium. These studies allowed Prof. DUAN's team to conclude that the pSI regulated a general aggressive state without affecting parenting and mating. These neurons might constitute a target for therapy in humans, both men and women.

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Prof. **PAN Jian-wei**, Executive Vice-President of the University of Science and Technology, speaking on "Quantum Communication: Past and Present," said that quantum computers were computers that use light instead of integrated circuits as it's the case in classical computers. These computers were believed to be fast and make few errors. Currently, China was developing its own quantum computers, such as the Jiuzhang 2.0 that could detect up to 250 photons, and used the Chinese *Zuchongzhi* microprocessor, composed of 66 functional qubits.

Quantum communication was already used to protect messages. Messages could not be cracked because human beings could not deduce states of quantum superposition of photons. 'Superposition of photons' means that a photon can influence another at a distance. These systems were not perfect and only worked for short distances, less than 10 km, and security was not perfect either, as parts of messages could be detected. Quantum repeaters may be needed along the path of a cable.

China had developed satellites for quantum communication, which might have many applications. Prof. PAN said that the Chinese Government was willing to train visiting scientists from Africa and other developing regions through 3–5-year grants.
